gauge, compound engines for pressures up to 150 Ib. per square inch, and triple-expansion engines for higher pressures.

In designing an engine, the size of the low-pressure cylinder is fixed first by assuming that the whole of the work is done therein by the steam expanding from the steam-chest pressure. The mean pressure which would then be developed is called the " mean pressure referred to the low-pressure cylinder " or " the mean referred pressure ". This quantity is the sum of the products of mean effective pressure by cylinder-ratio for each cylinder, the cylinder-ratio being defined as the ratio of the area of the cylinder in question to the low-pressure cylinder-area. The relation of the referred mean pressure to the initial pressure is a matter of some importance.

Formerly it was believed that the greater the number of expansions and the lower the mean pressure the higher the economy, but Willans experiments showed that it is not economical to carry the number of expan- sions beyond a certain point. It would obviously be wrong to reduce the pressure by expansion to a lower point than the back pressure on the other side of the piston. That is the first limiting condition even in a perfect engine. But in actual engines many conditions exist, such as wire-drawing, initial condensation, faulty release, over compression, leakage, incomplete expansion, high clearance volume, unresisted expansion between cylinders or " drop ", friction, &c., all of which reduce the thermal efficiency of the steam. Less power is obtained from a pound of steam than in a perfect engine, working, say, on the Rankine cycle between the limits existing in any particular case. If the defect of power can be regarded as an addi- tional and unavoidable back pressure, the number of expansions permissible is reduced. The better the engine, the less will be the effect of the dis- turbing conditions referred to above, and the greater therefore the number of expansions - and the lower the mean referred pressure to give maximum economy.

Willans gave certain figures based upon the results of his experiments, but they were obtained from an engine of small size and of exceedingly

special design, and would not necessarily apply to engines of greatly different types in which the effect of the factors mentioned above would all be much modified, even in different makes of the same type of engine.

For these reasons, the questions of the relation of the most economical " mean referred " pressure to initial pressures, cylinder ratios, &c., are dependent entirely on experience, and the results of tests of particular designs of engines. In the cases of triple-expansion engines with initial pressures of 150 to 200 Ib. per square inch, the ratio low-pressure cylinder/high-pressure cylinder may be from 4^ to 7 with mean referred pressures ranging from 34 to 44 Ib. per square inch condensing. The intermediate pressure-cylinder is usually made a mean proportional between the two. For compound condensing engines with initial pressures from 100 to 150 Ib. per square inch, the cylinder-ratio may be from 3 to 4^ with mean referred pressures from 32 to 40; when non-condensing, the ratio may be from 2 to 3 with mean referred pressure from 33 to 44. It is found